

Application No. 10/716,064

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Art Unit 3672

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REVISED CLAIMS (Revision # 5)

Rejected Claims 1 to 12 and 24 have hereby been abandoned.

Claims 13-23, 28-42 and 51 to 53 have been abandoned and replaced by new claims 66-70, for a method:

claims 43-50, 54-65, for an apparatus, still remaining.

I CLAIM:

43. An apparatus for continuously monitoring and controlling cyclic streams of various fluids, and of heat, in and out of four vertical, fluid-filled compartments, separated by at least two coaxial thermal barriers, in a multilateral well, equipped with a cemented casing pipe connected, via cemented curved liner pipes, to a plurality of quasi-horizontal branch-wells equipped with perforated liner pipes, for keeping said casing pipe at a below-freezing temperature, within a pre-existing cold environment, while heating, to maximum temperatures, fluids in said horizontal branch-wells, located in a originally-cool heavy-oil reservoir, below said cold environment and above a large portion of said heavy-oil reservoir, extending to a radial distance of at least five hundred feet, from the base of said cold environment, around said casing pipe, so as to:

- a) raise the fluidity of said heavy-oil reservoir fluids, by injecting at the well-head, hot wet steam supplied from the surface into said reservoir portion to heat its fluids' entire content and
- b) to re-heat and lift to the surface the fraction of said heated reservoir fluids, produced from said reservoir portion drained by the

producing branch-wells, mixed with a colder entire stream of re-heated fluids from said first compartment, wherein,

- said four compartments, inwardly-listed, along a radial direction, toward the multilateral well's axis, reach equilibrium temperatures, ranging from about -20 to -10 degrees C, in said, outermost, first compartment, in close thermal contact with said cold environment, and to about 150 degrees C in said gas-filled second compartment, at near atmospheric pressure, and up to 360 degrees C in a third and a fourth thin inward compartments, respectively gas-filled and steam-filled, comprising:

- a first, coldest, fluid-filled compartment, annular, between said vertical casing pipe and said first thermal barrier,
- a second, warmer, fluid-filled compartment, annular, adjacent to, and within, said first thermal barrier, containing production channels and a plurality of pipes dedicated to lifting, to said well-head, the hot fluids produced from said portion of heavy-oil reservoir, previously heated by injection of very hot steam,
- a third, hot, gas-filled compartment, annular and thin, at low pressure, containing monitoring sensors, adjacent to the inner side of said second thermal barrier, extending from the well-head to the lower end of each branch-well's curved tubing and within the space between said second thermal barrier's cover pipe and the fourth compartment,
- a fourth, very hot steam-filled compartment, coaxial tubular, highly pressure-resistant, preferably jointless, dedicated to carrying from the surface a high-pressure, very hot steam into each of those said branch-wells which operate in the steam injection mode.

44. The apparatus of claim 43, which, supplied by a continuous cold

gas stream from said well-head, first, subcools the cold environment,

- adjacent to said first compartment to strengthen the said cold environment crossed by the multilateral well casing, re-heated downhole, by mixing with a nearly continuous stream of hot oil and steam condensate, returns to the well-head, lifting hot heavy-oil and other produced fluids from a plurality of branch-wells to surface separators and provides, after separation, a large portion of the boiler-fuel required to make steam for heating said reservoir portion and its fluids content so as to drain and recover a significant fraction of said hot heavy-oil, wherein:

- said second compartment, preferably gas-filled, at a near atmospheric pressure and limited on its inner side by a shared annular production collector tubing, conveys to the well-head a mixture of hot reservoir fluids, produced from all the branch-wells operating in the production mode, together with the entire re-heated lift-fluid stream, at a nearly constant rate, with minimum external heat loss,

- a second thermal barrier occupying the space adjacent to the inner pipe of said annular production collector, filled with multi-layers of said super-insulation, sealed within a supporting steel pipe and a second metallic cover pipe, and with auxiliary flow-control devices, downhole, and at the wellhead, optimizes the cyclic periods durations, to regulate the production rate within the production collector tubing within said second compartment, at minimum heat loss to the cold environment,

- said third compartment continually monitors and records pressure, temperature and the near-absence of water content of the gas filling said third compartment,

- the fourth compartment, steam-filled, at high pressure and high temperature, directly coupled to a steam generator outlet, continuously conveys steam of high quality, downhole, for safety and reliability of a high-energy process, within the multilateral well.

45. The multiple uses of fluids in the apparatus of claim 44, wherein:

- said mixture of re-heated lift-fluid and hot reservoir fluids (oil, water and solution gas), continuously produced from branch-wells in the production mode and carried to the well-head, within said second compartment, via a shared production collector tube, finally processed in separators, provides oil for shipment, and fuel and water for generating steam and electric power, in close proximity of the multilateral well site, and
- said gas circulating in a close circuit, from the well-head, and back, filling said third compartment, together with appropriate downhole sensors, enables to detect, locate and repair any potential steam leak into said second thermal barrier's insulation.

46. The apparatus for avoiding external heat losses and for improving fuel economy of claim 44, wherein:

- said first thermal barrier consists of an intermediate pipe supporting a sealed first annular layer of thermal "super-insulation", as defined by its very low thermal conductivity, due to its nanoporous structure, combined with a reduced transfer of radiant heat, so that the fluid temperature in said first compartment always remains much below freezing, thereby sub-cooling the surrounding cold environment, beyond said outer casing,
- said supply of a pressurized cold gas stream, actually, gains heat

from the cold environment, and the same gas stream's expansion, facilitates the liberation of solution gas from said hot heavy-oil stream; both gas streams together provide the energy required for lifting the liquids production stream to the well-head and, after their recovery from the separators, they contribute most of the required boiler-fuel, at a low total cost.

47. The apparatus of claim 44, for applications to cold environments, Onshore, in the Arctic, where known heavy-oil reservoirs are located below a Permafrost zone of about 1,800 ft-thickness, and Offshore, to large heavy-oil reservoirs, discovered but not exploited, below a cold deep sea, wherein the insufficient fluidity of the heavy-oil in said reservoirs prevents it from reaching commercial-production.

48. The apparatus of claim 43, wherein said plurality of tubing pipes dedicated to carrying hot produced fluids are mostly parallel and located in part within an insulated vertical casing and partly within a curved cemented liner of a branch-well.

49. The apparatus of claim 43, wherein said plurality of tubing pipes dedicated to carrying hot produced fluids are coaxial, entirely within said insulated vertical casing of the multilateral well.

50. The apparatus of claim 44, for controlling, or interrupting, flow of fluids, and of heat, downhole, includes various pre-fabricated elements, shipped to and installed, on-site from the earth surface, Onshore and Offshore, in various parts, listed in the order of their installation:

- part 1: the well-head and the cemented casing pipe of a substantially vertical heavy-oil well, crossing a cold environment, and said vertical well casing pipe connecting in its lower part, downhole below said cold environment, to:

- part 2: a plurality of cemented branch-wells, each presenting a curved portion of liner pipe string, and each connecting to:

- part 3: a nearly horizontal, perforated portion of a liner pipe, in each branch-well, and wherein:

for each branch-well, said apparatus includes two main connecting modular tubular elements, installed by means of a conventional rig:

respectively, the first element within said curved part of said liner pipe string, and the second element within a portion of said insulated vertical casing, dedicated to said branch-well, providing said downhole flow-connecting means:

A. to connect both said modular elements with a quasi-horizontal tubing string, within part 3, hung in said branch-well's perforated liner and via the non-perforated, cemented curved liner string of part 2, to the annular third compartment of part 1, around said horizontal tubing string, in said liner pipe,

B. to connect both said elements with a vertical tubing string, behind a sealed super-insulation of thermal conductivity and radiant heat transfer of 25 milli-Watt/meter-degree K, at up to 260 degree C, designated as the second thermal barrier, and dedicated to conveying downwards a stream of wet steam from said vertical well's well-head to the most distant end of said horizontal tubing string,

C. to connect both said elements through said third compartment, at

near-atmospheric pressure used as a thermally-insulated tubing string, behind a sealed super-insulation, designated as the first thermal barrier, and said tubing string dedicated to transporting upwards the hot fluids, produced from said branch-wells, to said vertical well's well-head,

D. to connect both said first and second elements with one or more oil-lifting-fluid vertical feeder tubing strings, dedicated to carrying downwards a pressurized cold stream of oil-lifting-fluid, from the vertical well-head via the casing's first annular compartment around said super-insulated tubings, to the said two elements of each branch-well,

and for providing said downhole flow-interrupting means:

E. to periodically interrupt, with surface-operated valves, or with retrievable plugs, in said apparatus, the respective flow-streams:

a) of steam from the surface into said quasi-horizontal tubing string, and, successively:

b) of heated oil-lifting-fluid from said curved liners up to the surface, and

c) of reservoir fluids produced from the tubing pipes of said branch-wells into said apparatus up to the well-head.

54. The pre-fabricated apparatus of claim 48, installed in each branch-well and in a dedicated portion of said vertical well casing includes a first modular element, and a second modular element,

wherein,

said first modular element includes means :

a) to establish connections to a conventional tubing, installed in the quasi-horizontal part of each said branch- well,

- b) to establish connections to the annular space around said conventional tubing, within said branch-well,
- c) to deliver steam into said annular space, from said second modular element, for the subsequent injection and soaking of said steam into said heavy-oil reservoir,
- d) to establish connections to said second modular element of said apparatus, located above said first modular element, primarily within said portion of the vertical well casing dedicated to said branch-well,
- e) to convey a heated oil stream flowing from said reservoir into said conventional tubing and into said tubing's annular space, via the first modular assembly element, to said second modular assembly element, using a natural steam-lift and various artificial oil-lifting systems.

55. The apparatus of claim 54, wherein a second modular assembly element, comprising parts two and three of said apparatus, and connected to the first modular assembly element of said apparatus, includes, in its part two:

- a production tubing, equipped, at its bottom end, with a second sealing stinger, matching the second polished-bore-receptacle,
- an oil-lifting-fluid supply tubing, equipped, at its bottom end, with a third sealing stinger, matching the third polished-bore-receptacle, and connected to a third part of said second modular assembly element of the apparatus for said branch-well; and said apparatus includes, in its part three, from the bottom-up, and
 - means for remotely operating said natural steam-lift and

artificial oil-lift systems in the sequential steam injection, steam soak and oil production modes, using various combinations of said branch-flow connections,

- means for automatically closing said first branch-flow connection, when said annular space is filled with lower density fluids, such as steam or oil-lifting-fluid of low density,

- means for establishing the following branch-flow connections by opening valves or by plug removal,

- A. from the first annular compartment to a coaxial, un-insulated, production collector pipe, when said first annular compartment is mostly filled with liquids (oil and water),

- B. from said production tubing to a central, insulated steam tubing, during the steam injection period, in said branch-well,

- C. from said production tubing to said central production collector pipe, during the branch-well's production period,

- D. from said production tubing to an oil-lifting-fluid supply tubing, parallel to the production tubing, and located in a different radial plane than said production tubing,

- E. from said oil-lifting-fluid supply tubing to a vertical string of oil-lifting-fluid feeder tubings, rising through the multi-tubular packer at the top of said casing annular space's portion, dedicated to said second and third elements of said branch-well's apparatus, and crossing those portions of the casing's annular space stacked above the annular space of said branch-well, and dedicated to other branch-wells.

56. The apparatus of claim 54, wherein each said branch-well includes a quasi-horizontal portion, equipped with a perforated liner string,

cemented or not, coupled to a larger diameter curved liner string, cemented from its lowest point to a side-way liner stub, of even larger diameter, always cemented and sealed into the large casing of the vertical multilateral well, and containing a hanger-packer, sealing the upper end of said curved liner string, into said liner stub,

wherein said liner string contains, in its quasi-horizontal portion, a centralized single tubing string, hung, at its proximate end, via a thermal expansion joint, into the bottom part of said curved liner string, terminated at its upper end by a first polished-bore-receptacle, above a cup packer, used as back-flow preventer, and a first landing nipple and its matching retrievable plug,

wherein, the first modular element of said apparatus includes two parallel curved tubing strings, coupled together, at their lower ends, to the upper branches of an H, or Y, connector, whereas a lower branch of said first H, or Y, connector, leads to a first tubular stinger, equipped with seals, and inserted in said first polished-bore-receptacle, and the other lower branch of said H connector is plugged-off,

wherein, one of said two parallel curved tubings is dedicated to supplying a lighter oil-lifting-fluid to oil-lifting devices, respectively delivering said oil-lifting-fluid to the other curved tubing string, used as production tubing, and to the annular space between said curved liner and said curved tubings,

wherein, the upper end of said curved production tubing is equipped with a second polished-bore-receptacle,

wherein, the upper end of said curved

oil-lifting-fluid supply tubing is equipped with a third polished-bore-receptacle, to offset the thermal expansion of said oil-lifting-fluid supply tubing.

57. The apparatus of claim 50, wherein said means for remotely operating said steam-lift and oil-lifting systems in the sequential steam-injection, steam-soak and oil-production modes, using said branch flow connections, include, from the top down:

A. a retrievable plug, located in a second landing nipple, in the production tubing, closing said fifth branch flow connection, except when logging or cleaning tools are to be introduced into said branch-well's production tubing,

B. a surface-operated conventional "on-off" valve opening or closing said fourth branch flow connection of said oil-lifting fluid supply tubing with said oil-lifting fluid feeder tubing string,

C. a surface-operated 3-way valve, vertically located in the production tubing, below said second landing nipple and plug, either directing a production fluids stream upwards into said third branch flow connection to the production collector pipe, or directing steam downwards from said "super-insulated" steam tubing, via said second branch flow connection, into the branch-well's production tubing;

and wherein said means for, automatically, closing said first branch flow connection, from said casing annulus portion to said production collector pipe, include:

- a float valve, or a standing valve, set in a gas-lift valve mandrel within said oil-lifting-fluid supply tubing, from which said valve automatically directs, by an artificial oil-lifting process

a stream of production fluids from the casing annulus portion, via said first branch flow connection, to the production collector pipe, when the level of high-density produced liquids is high within said casing annulus portion, above said liner stub, and said float valve or standing valve also closes said first branch-flow connection, when said produced liquids level is low, due to the accumulation of steam, of gas, or of oil-lifting fluid, within said casing annulus portion, during the steam injection period, and by a natural steam-lift, during the steam-soaking period.

58. A dedicated super-insulated tubular assembly, of claim 54 for conveying wet steam, with minimum heat losses, from a generator at the surface, to one or more of a plurality of branch-wells, connected to a single large cemented oil well casing pipe, hung from a large single well-head, wherein,

said tubular assembly includes, radially, from the axis of said casing pipe:

- a pressure-resistant, leak-proof, metallic central tubing string, made-up of joints coupled together, end to end, by threaded couplings, and hung in the well-head,
- a coaxial annular layer of nanoporous super-insulating fibrous or granular materials, of very low density, filled with gas at near atmospheric pressure, and presenting a highly reduced radiant heat transfer,
- a coaxial sealed insulation cover and support tubing string, also hung in the well-head, made-up of thin-gauge metal joints, welded or brazed together, surrounding said annular layer of super-insulating material and said thin-gauge metal joints presenting a flexible

annular support welded respectively to the outer surface of said central tubing and to the inner surface of said insulation cover tubing, at the respective two ends of each joint of said tubings,

- a plurality of wire-type metal centralizers, affixed to each joint of said central tubing, within its associated thin-gauge metal joint and each said centralizer presenting a radial extension, sliding into a rail guide affixed to the inner surface of said thin-gauge metal tube, parallel to its axis,
- a coaxial pressure-resistant protective metallic tubing string, made up of tight joints, coupled by metal to metal threads at each of their two ends, also hung in the well-head and presenting an inner diameter slightly greater than the outer diameter of said sheet metal tubing string,
- two coaxial stinger tubes, equipped with heat-resistant seals, for insertion of each of them into a matching polished-bore-receptacle, respectively at the lower ends of said central metallic tubing string and of said coaxial outer protective metallic tubing string.

59. The dedicated super-insulated tubular assembly of claim 50,

wherein:

the sealed annular enclosure of said super-insulating materials, comprises:

- A. metal wire centralizers, or radial extensions,
- B. longitudinal metal guides, rails or grooves,
- C. thin-gauge metal tubulars, and
- D. metal flexible annular supports,

together with either the outer surface or the inner surface of an adjacent steel tubular,

and wherein,

- said metals are selected alloys, including two or more metals, taken from the following alphabetic list:

Aluminum, Antimony, Cadmium, Copper, Chrome, Iron, Manganese, Molybdenum, Nickel, Silicon, Silver, Titanium, Vanadium and Zinc, for their cost, and respective compatibilities, and for their main relevant properties, within the temperature range of 100 C to 300 C, said properties being listed below:

- ease of assembly by welding, brazing, or soldering,
- maximum elongation, by cold-working in dies,
- high structural strength, ductility, and fatigue resistance, of said thin-gauge metal tubulars,
- low thermal conductivity and low thermal expansion, relative to those of high-strength steel or of plating metals of said steel tubulars.

60. A modified version of the super-insulated steam tubular assembly joints of claim 50, also pre-fabricated,

wherein,

- said outer protective tubing joint, is used as the main structural support of the super-insulation and of said insulation cover tube, made of thin-gauge metal, and as a substitute to the inner steam tubing,

wherein,

- a jointless coiled-tubing string, straightened by conventional means, is inserted within said welded insulation cover tube, thereby eliminating the risk of steam leaks, present in jointed tubulars, at high temperatures,

and wherein,

- A. said wire-type centralizers are affixed on the inner surface of said protective tubing joint, with their radial extensions pointing inward,
- B. said extensions are sliding in rail guides affixed to the outer surface of the thin-gauge metal cover tube, of diameter only slightly larger than that of said coiled-tubing,
- C. said flexible annular end-supports of the thin-gauge metal cover tube are affixed respectively on the inner surface of the protective tubular, and on the outer surface of said thin-gauge metal cover tube, thereby sealing the insulation inside a thin-gauge metal annular enclosure, fully protected from external shocks, by the thick outer protective pipe,
- D. the annular space between said coiled-tubing outside diameter and the drift diameter of said thin-gauge metal insulation cover tubes, does not exceed one sixteenth of an inch, plus a plurality of pairs of grooves containing jointless stainless steel micro-tubes of one quarter-inch diameter, protecting fiber-optic or electronic cables linking recorders at the well-head to downhole sensors, of temperatures, pressures, humidity and other control parameters of the fluids flow-rates and heat transfer processes, in the entire system,
- E. a low-pressure slip-stream of dry oil-lifting fluid, filling said annular space, in case of a small leak, carries away and prevents any potential moisture leakage from contacting said insulation.

61. The coiled-tubing, used as the steam tubing string in claim 54, is preferably made of a seamless tube of Titanium or of Laser-welded Chrome and Nickel alloy steel, wherein,

- said jointless coiled-tubing is equipped at its lower end with a sealing stinger matching an associated polished-bore-receptacle above the packer of the uppermost apparatus, leading to the central insulated steam tubing, previously hung within the stack of all the branch-wells' apparatus.

62. The super-insulated coaxial production tubular string of claim 50, conveying heated oil to the surface, together with steam condensate and oil-lifting fluid, built on a larger radial scale, proportional to the entire fluid volume rate lifted from all the branch-wells, simultaneously producing within the shared production collector pipe, so that the annular space between the inner diameter of the production collector, in said coaxial production tubular assembly, exceeds, by two inches or more, the outside diameter of the steam tubular assembly's protective tubing string, which hangs, coaxially, within said production collector pipe string,

wherein,

- in view of the heavy weight of the production tubing joints, the preferred configuration is that of a coaxial production tubular string of pre-fabricated joints,

wherein,

- "slick" production tubing joints, of outside diameter slightly smaller than the drift-diameter of the super-insulation thin-gauge metal cover tubes, are separately shipped to the well site, coupled together on the rig, silver-soldered at the threaded joint, and the resulting production tubing string is run into said pre-installed and, graphite-lubricated, insulation cover tubes, firmly supported within their outer protective tubular string, by wire centralizers and

their radial extensions sliding in longitudinal guides, by flexible end collars and by seam welds at the junction of each thin-gauge metal joint,

wherein,

- a slip stream of scavenging dry oil-lifting fluid of low density, circulates in the very thin annular space between the outer surface of said protective tubular string and the inner surface of said insulation cover string, to dilute and carry-away to the surface any accidental entry of moisture into said very thin annular space, to prevent said moisture from potentially breaking through the thin-gauge metal of the sealed insulation cover string, and

wherein,

- the lower end of the outer protective tubular string of the production tubular assembly is closed by a welded ring, equipped on the inside with circular seals, through which slides the production tubing string, above its lower-end stinger, sealed within a matching polished-bore-receptacle, affixed to the top end of the un-insulated production collector pipe, affixed to the uppermost multi-tubular packer of all the stacked apparatus, set within the vertical well casing.

63. The apparatus of claim 44 wherein the cold oil-lifting-fluid, mostly composed of water-free, mixed, light hydrocarbons, when re-heated, is partly miscible with the heated and produced heavy-oil and carried to the surface by means of artificial-lift devices, as both gas and liquid phases.

64. The apparatus of claim 44 wherein said oil-lifting fluids are

in a gas phase and said artificial-lift devices are conventional, wireline-retrievable gas-lift valves, set in regular gas-lift valve mandrels and operated by the density difference of said gas phase versus the densities of said heated oil and of said steam condensate, wherein:

- the temperature of said oil-lifting fluids is closely monitored by appropriate sensors located downhole and recorded at the surface, throughout the operation of each of the branch-wells, until said oil-lifting fluids return to the surface, to be separated out as part of the boiler-fuel, and used to generate steam.

65. The apparatus of claim 47, wherein:

- said oil-lifting fluids, when cold, are in a light liquid phase and said artificial-lift devices are set in suitably modified gas-lift valve mandrels or anchored in a landing nipple included in said oil-lifting fluids feeder tubing and operated by the differential pressure of said light oil-lifting fluids, across said artificial-lift devices, including:
 - A- progressive cavity pumps,
 - B- hydraulic pumps,
 - C- jet pumps.

66. A method of producing viscous heavy-oil from a cool reservoir located below a cold environment, into a multilateral well equipped with a plurality of branch-wells, said multilateral well having a cemented casing traversing said environment and connected to liners of said branch-wells, located below said environment, said method comprising the steps of:

a) sub-cooling said cemented casing with a compressed gas stream, colder than said environment, flowing downward in the annular space, herein designated as a first flow-compartment, located between the inner surface of said cemented casing and the outer surface of a thermally-insulated intermediate pipe of smaller diameter than said casing's inner surface,

b) re-heating said cold gas-stream by adding it to a mixture of hot liquid production stream, flowing upwards from most of said branch-wells and of a very hot condensate stream, coalesced from a stream of wet steam, flowing downwards in a thermally-insulated tubing, located on the axis of said casing and on the axis of at least one other branch-well, from which said wet steam, partially separated from said condensate, is injected into a portion of said cool reservoir, via the tubing of a first-steamed injector branch-well,

c) subsequently stopping the steam injection in said first-steamed branch-well, and transferring said steam injection to a second-steamed branch-well, to let the first injector's steam to rise up, by gravity within said reservoir, above said first injector branch-well, thereby heating said reservoir's portion and reducing the viscosity of all its fluids content, during a steam-soaking period, in which the heated liquid fluids (oil, water and condensate) flow in counter-current of the rising steam, first within said reservoir portion and then into a horizontal part of the first-steamed branch-well's curved tubing,

d) subsequently gas-lifting said heated liquid fluids into the curved part of the tubing of said first-steamed branch-well, up to said curved tubing's junction with a shared annular collector channel, in a thermally-insulated space, gas-filled at near-atmospheric pressure,

herein designated as a second flow-compartment, located between two coaxial thermal barriers, said collector channel being always opened to all producing branch-wells and up to the end of said channel, at the well-head, and connected to multiple parallel tubings via flow-control devices for, sequentially, switching each branch-well to different operating modes,

e) separating the gas phase (gas-lift gas and solution gas) from the gas-lifted liquid phases (hot oil and water) in a three-phase separator system, at the surface,

f) piping the separator off-gas phase to the boiler-fuel feed manifold to generate a large portion of the required steam, the remainder of said required steam being supplied by an additional portion of said compressed cold gas supply stream,

g) treating most of said separated hot water phase for making it into the supply of boiler feed-water, and using excess water for heating facilities at the surface, and for waterflooding other reservoirs,

h) disposing of waste streams (boiler sludge, chemicals, etc...) in a shallow disposal well,

i) shipping the off-separator, hot heavy-oil phase, to mix it with lighter crudes, thereby making a mixture suitable for pipeline and tanker transportation, to a refinery,

j) successively repeating the same sequence with various other branch-wells, optimizing the respective durations of the main periods, respectively: steam-soaking, lasting a few days,

steam-injection, lasting a few weeks,

oil producing, lasting several months, and

depending upon: the number of available branch-wells, the reservoir characteristics, the heat transfer rates and the tubular length and

sizes, for each particular case, from operating data collected from multiple sensors, at the surface and downhole, within a thin, but important, annular space adjacent to said second thermal barrier, herein designated as a third flow-compartment, and the steam-filled tubing string, herein designated as a fourth flow-compartment of the multilateral well.

67. The method of claim 66, for injecting wet steam, made on site, via one or more of said branch-wells in said heavy-oil reservoir, via a dedicated and shared "super-insulated" steam tubular assembly, coaxially located within said vertical cased well, said method comprising the following steps:

- a) opening a steam valve at the well-head, from the insulated goose-neck steam supply line pipe from a boiler, to the axial jointless tubing located within a thin metallic cover tubing around said thermally-insulated steam tubing, said annular space between said insulation cover tubing and said jointless steam tubing being gas-filled at near-atmospheric pressure, herein designated as an instrumented third flow-compartment for optimizing the respective durations of steps b), c), d), e), f) and j), of claim 66, so as to maximize the heavy-oil average production rate, in daily Barrels per daily million BTU of cold gas, consumed by said multilateral well,
- b) opening a valve, located downhole, on a slanted connecting pipe, linking the steam-filled axial pipe to the tubing of the branch-well selected as second-steamed injector,
- c) closing the annular space between liner and tubing at the lower end of the curved part of the selected branch-well by applying fluid-pressure on the upper face of its cup-packer, thereby preventing

any back-flow of steam above said cup-packer, during the steam injection period and the steam-soaking period.

68. The method of claim 67, wherein:

- the fluid filling said first flow-compartment is always a downhole-flowing stream of dry boiler-fuel, gaseous or liquid, of high fluidity and low market value, at a below-freezing temperature, with a flow rate and a temperature remaining almost constant, and

wherein,

- on the contrary, the streams of warm fluids, filling said annular production tubing are periodically changing, thereby creating thermal stresses which, in deep wells, handling corrosive heavy-oils, might reach, after many repeated stress cycles, the fatigue limits of the metals used in said multilateral well; heavy-oils rich in wax and asphaltenes might also plug-off the well's tubings and even the sand face, so additional preventive steps will extend those of claim 66:

A) interrupting downhole the production flow stream from the horizontal branch-well annulus, by closing a lift-gas supply valve, or inserting a corresponding wireline-retrievable plug and

B) compressing, warming and injecting into the branch-well lift-gas tubing, a downhole-flowing mixed stream of said boiler-fuel, gas or liquid, re-heated by heat-exchange with very hot steam condensate, separated-out from wet steam, and dehydrated, at the surface,

C) injecting said dry mixed stream into the annular space of the branch-well for a short oil-cleaning period, thereby displacing warm gas in the annular production tubing, and in the annular space of the horizontal branch-well, ahead of steam injection, via the branch-well tubing, and trapping some of the said warm gas in both the branch-well tubing and its surrounding annular space, for a period of a few days,

D) gradually increasing the heat transfer rate to the branch-well's horizontal and curved tubings and to the perforated horizontal liner string of the branch-well, and pre-heating the reservoir around the horizontal branch-well, before reaching the full rate of steam injection,

E) injecting, at full rate, a downhole-flowing stream of wet steam in said branch-well, for a selected period, of about a few weeks

F) closing the steam valve at the well head, for a short steam soaking period, of a few days, to form a steam chest, in the reservoir,

G) returning the multilateral well to its original branch-well oil-flow configuration, and, finally:

H) starting a new cycle of heavy-oil production, lasting at least several months, or longer, depending upon the porous volume and other characteristics of said reservoir portion, and lasting until the heavy-oil production rate from said branch-well rapidly declines, due to shrinkage of the steam chest, by steam condensation, whithin the actual drainage volume of the branch-well.

69. The method of claim 66, wherein:

the gas filling said second flow-compartment is dry Nitrogen gas, at a near-atmospheric pressure, so as to further reduce the residual heat transfer from said production collector pipe, via said first thermal barrier to said first flow-compartment.

70. The method of claim 66, wherein:

the gas filling said third flow-compartment, of very small volume, is pure dry Argon gas, at a near-atmospheric pressure, so as to further

reduce the residual heat transfer, via said second thermal barrier to said second flow-compartment, and also to detect, by spectral analysis of said Argon gas, any leak of steam, or of Nitrogen gas, or of Methane gas, from the other, higher-pressure flow-compartments, or to detect any Hydrogen gas resulting from corrosion of the metals of any of the pipes surrounding said third flow-compartment.